CHRISTENSEN ASSOCIATES

Supplemental Declaration of

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INTRODUCTION

We are Dr. Mark E. Meitzen and Dr. Philip E. Schoech of Christensen Associates. We previously submitted an assessment of the FCC's proposed options for the special access price cap X factor in which we concluded that the BLS KLEMS method is the best approach for establishing the X factor. We also concluded that among the different time periods under consideration for calibrating the X factor, the 2005-2013 period was the most appropriate. Over the 2005-2013 period the BLS KLEMS method produced an X factor of 1.95%.[1] On August 9, 2016, we submitted reply comments that provided information on updates that the BLS had recently made to the KLEMS database and we calculated a revised X factor of 1.99% using these updated data for 2005-2014. In our reply we also critiqued the Declaration of David E.M. Sappington and William P. Zarakas submitted on behalf of Sprint Corporation.[2] We concluded that their proposal, based on EU-KLEMS data was misinformed and was generally an ill-considered alternative to BLS KLEMS for calculating the X factor proposed in the FNPRM.[3]

The purpose of this Supplemental Declaration is to respond to the Declaration of Chris Frentrup and David E.M. Sappington (hereafter, "F&S") submitted on behalf of Sprint Corporation on August 31, 2016.[4] In their Declaration, F&S provide a proposal for the special access X factor that is based on the BLS KLEMS measure of TFP and a convoluted measure of input price growth that employs, in part, estimates of input price growth that were developed several years ago by FCC staff in response to a peer review of the CACM.[5] In arguing for use of CACM-related input price growth estimates, F&S make modifications to estimates reported in the peer review response that they believe address shortcomings in the calculation of capital input prices and operating expenses. However, despite their modifications to these estimates, F&S have not overcome fundamental deficiencies of employing CACM-related measures of input prices for use in computing the special access X factor. These deficiencies include:

- the violation of fundamental economic consistency relationships between TFP and input prices;
- a mismatch between KLEMS TFP and CACM input price definitions and proportions on multiple of levels;
- the development of an *ad hoc* and poorly documented historic input price series that reflects neither actual BDS costs nor economic costing principles; and
- a resulting wide-ranging, internally inconsistent and unreliable hypothetical input price series.

F&S have not resolved, nor can they resolve, fundamental deficiencies of the CACM model as a basis for industry input prices used to compute a special access X factor. In our opinion, only the BLS KLEMS

[1] Mark E. Meitzen and Philip E. Schoech, "Assessment of the FCC's Proposed Options for the Special Access Price Cap Factor," June 28, 2016.
[2] Declaration of David E.M. Sappington and William P. Zarakas, June 28, 2016.
[3] Reply Comments of Mark E. Meitzen and Philip E. Schoech, August 9, 2016.
[4] Declaration of Chris Frentrup and David E.M. Sappington, August 31, 2016.
[5] It is our understanding that the base input price growth estimates that F&S associate with CACM found in Appendix C of the FNPRM are not original CACM inputs or outputs developed by CostQuest, but rather are based on FCC staff processing of information external to CACM. See Federal Communications Commission, Erratum, WC Docket Nos. 16-143, 15-247, 05-25 and RM-10593, May 26, 2016. Also see Federal Communications Commission, Peer Review of Connect America Phase II Cost Model, FCC Response to Professor Christiaan Hogendorn. Available at https://apps.fcc.gov/edocs_public/attachmatch/DOC-322385A1.pdf.

measure of TFP along with its consistent accompanying input prices is an appropriate option for use in computing the BDS X factor.

BLS KLEMS TFP AND KLEMS INPUT PRICES PROVIDE THE APPROPRIATE MEASURE OF THE SPECIAL ACCESS X FACTOR

We have previously concluded that the BLS KLEMS method and its dataset, which generate consistent measures of TFP and input price growth, is based on sound economic principles and represents the best methodology and data for measuring the special access X factor. Additionally, we have provided ample reasons why national CACM input proportions and related input price growth rates (regardless of the TFP figure they are paired with) do not provide an accurate or consistent basis on which to compute the special access X factor.

On behalf of Sprint Corporation, F&S have taken issue with these conclusions. They note that BLS KLEMS measures for TFP and input price growth apply to the combined Telecommunications plus Broadcasting industry. They state that while they accept BLS KLEMS figures as the best available for BDS TFP, they claim that they have developed a series for input price growth that they believe is more BDS-specific than the BLS KLEMS input price series. F&S then argue that the Commission should calculate a BDS X factor using BLS KLEMS for TFP, but using F&S's series for input price growth. While F&S recognize that employing such a mismatch of data violates fundamental economic and mathematical principles for consistency between measurements of TFP and input prices, their proposal is based on the premise that their input price data are such a better match to BDS than the BLS KLEMS measure of input prices that it is worth jettisoning these principles.[6]

However, F&S's eclectic proposal:

- Is impermissible from the point of view of economic theory and mathematical consistency;
- Would not alter the X factor calculated from use of BLS KLEMS data for both TFP and input prices because any reduction in assumed input price growth to make it "more BDS-specific" would require an exactly offsetting reduction in calculated TFP to make it equivalently BDS-specific;
- Would also be misguided from an empirical accuracy perspective because there is no reason to believe that F&S's proposed input price index is more accurate as to BDS than is the input price index calculated by BLS KLEMS.

Because of this, there is nothing in the F&S Declaration that causes us to alter our prior conclusion that BLS KLEMS TFP coupled with BLS KLEMS input prices provides both the theoretically appropriate and the empirically most accurate basis on which to compute the special access X factor. Indeed, examination of F&S's Declaration brings out multiple reasons why the BLS KLEMS TFP input price growth index is wholly superior on both theoretical and empirical grounds to employing the input price growth index proposed by F&S.

[6] Declaration of Chris Frentrup and David E.M. Sappington, August 31, 2016, p. 6.

A FUNDAMENTAL INCONSISTENCY EXISTS BETWEEN BLS KLEMS TFP AND THE INPUT PRICE GROWTH SERIES USED BY F&S

F&S propose that the BDS X factor be established by combining the BLS KLEMS figure for TFP growth with an input price growth series they develop using national CACM capital input proportions and an incongruent mix of price growth estimates for a small fraction of the literally thousands of input parameters contained in the CACM model. While F&S note that input proportions and price growth rates associated with the CACM (that models a network devoted primarily to providing residential FTTH broadband and voice services) "may not parallel BDS price growth rates exactly," they claim these figures (which they largely misidentify as CACM "data") "provide a viable alternative to the BEA/BLS input price growth data."[7] F&S's sole basis for claiming that these input price growth estimates are superior to those developed by BLS KLEMS rests on the assertion that because CACM is a model of a wireline network, its input prices and proportions "are *likely to better reflect* BDS input price growth rates."[8]

While we reject the validity of this assumption, which has been advanced without any supporting theoretical or empirical evidence, assume for the moment that it is true. The question remains whether it is appropriate from a mathematical and economic perspective to merge these CACM-related input price growth estimates and proportions with the TFP measure developed by BLS KLEMS for the purpose of developing a BDS X factor. We find that merging these disparate data is impermissible from a mathematical and economic standpoint. However, if F&S's alternative input price series is to be used to provide a claimed more BDS-specific X factor, this alternative input price series must also be used to develop a more BDS-specific value for TFP. We demonstrate that using such an alternative input price series to calculate TFP will imply a downward adjustment to TFP that will exactly cancel out the upward effect on the X factor caused by this series' use in the X factor calculation as advocated by F&S.

Economic Principles: TFP and Input Prices Are Inextricably Linked

An elementary but fundamental relationship in economics used in the measurement of TFP is that costs (or revenues), prices and quantities are inextricably linked through the following identity:

(1) Cost (or Revenue) = Price x Quantity

Focusing on output quantities, this fundamental dual relationship between quantities and prices is given by:

(2) Output Quantity = Output Revenue/Output Price

Thus, the growth in output quantity is given by:

(3) Output Quantity Growth = Output Revenue Growth – Output Price Growth

Focusing on input quantities, this fundamental dual relationship between quantities and prices is given by:

(4) Input Quantity = Input Cost/Input Price

[7] Declaration of Chris Frentrup and David E.M. Sappington, August 31, 2016, p. 5.
[8] Declaration of Chris Frentrup and David E.M. Sappington, August 31, 2016, pp. 5-6 [emphasis added].

Thus, the growth in input quantity is given by:

(5) Input Quantity Growth = Input Cost Growth – Input Price Growth

Finally, total factor productivity growth is defined as the growth in output quantities relative to the growth in input quantities:

(6) TFP growth = Output Quantity Growth – Input Quantity Growth

In developing measures of TFP, there are rarely good, comprehensive measures for physical input or output quantities. Thus, BLS relies on dollar measures of output revenues and input costs along with Equation (2) and (4) duality principles to establish quantity indexes for outputs and inputs. That is, data on costs of inputs is divided by data on prices of these actual inputs to determine the relevant input quantity index. Similarly, the output quantity is developed by dividing output revenues by the price of these actual outputs. Substituting Equations (3) and (5) into Equation (6) leads to the following equation for TFP growth:

(7) TFP Growth = [Output Revenue Growth – Output Price Growth]
– [Input Cost Growth - Input Price Growth]

Note that Equation (7) demonstrates that TFP growth is directly proportional to input price growth. The mechanism behind this relationship between input prices and TFP is simple. If (as F&S claim) input price growth is less than previously thought, this means (via Equation 5) that input quantity growth must be greater than previously thought and, thus (via Equation 6), TFP growth is less than previously thought. Further, the downward change in estimated TFP growth matches exactly the downward change in claimed input price growth.

This demonstrates that it is a "zero-sum game" to change the input price index for the purpose of affecting the magnitude of the X factor. This is evident by taking note of the fundamental relationship between X, industry TFP, and industry input prices given in paragraph 405 of the FNPRM and repeated in paragraph 3 of Appendix C of the FNPRM:

(8) X Factor = GDP-PI Growth – Industry Input Price Growth + Industry TFP Growth

Just as Equation (7) shows that any alteration to input price growth creates an equivalent change to calculated TFP growth, Equation (8) shows that this change in TFP growth will exactly offset the direct effect on X from the change in input price growth – and leave the resulting X factor unchanged.

Implications of this Fundamental Relationship Between TFP and Input Prices

In the current case, assuming that input price growth in equation (7) changes, the differential in input price growth between BLS KLEMS and the F&S index translates into an offsetting change in TFP growth, resulting in no change in the X factor. Thus, ignoring the fact that the input categories and proportions from CACM used by F&S are different than those in BLS KLEMS, F&S's midpoint input price growth figure of -0.09% is 1.58% less than the KLEMS input price growth of 1.49% over the 2005-2014 period (the period we advocate for X factor measurement). But when F&S's lower input price growth figure of -0.09% is inserted into Equation (7), this implies a TFP growth rate that is 1.58% less than the BLS KLEMS calculated rate of 1.60% for 2005-2014. And when the resulting value of 0.02% for TFP is used in

Equation (8) along with F&S's figure of -0.09% for input price growth, it generates an X factor that is precisely unchanged from its previous value.[9] While F&S may attempt to argue that they should not be required to insert their alternative input price growth figure into Equation (7) to re-compute TFP, this demonstrates the importance of not mismatching data sources. And it also demonstrates the significant burden of proof that F&S are assuming by adopting their input price series and, in the process, jettisoning the principle of economic duality. This burden of proof is never addressed by F&S.

In any event, there are empirical economic sanity checks that could demonstrate whether F&S's proposed input price index is consistent or inconsistent with the BLS KLEMS measures for TFP and input price growth, which F&S accept as accurate for the telecommunications plus broadcasting industries. We find that rather than demonstrating that the F&S input price index is consistent with other KLEMS data and comport with empirical observation, these checks indicate F&S's index to be at odds with reality.

The first check relates to necessary mathematical relationships between input price and output price growth in various subsectors of the combined telecommunications and broadcasting industries. As mentioned above F&S's -0.09% estimate for "wired telecommunications" input price growth combined with their acceptance of 1.49% input price growth for the total broadcasting and telecommunications industry over the 2005-2014 period implies a very substantial rate of input price growth for the portion of the total industry that is not "wired telecommunications." For example, given that wired telecommunications accounts for roughly 51% of the combined industry, the F&S assertion that wired input prices declined by -0.09% implies that broadcasting and non-wired telecommunications input prices must have increased by roughly 3.0% per year.[10] Given the significant improvements in wireless technologies relative to wired technologies over this period, this simply does not make sense and

[9] Note that incongruously, F&S choose a longer 1997-2014 test period for the X factor, but adhere to the 2005-2014 test period for computing a going-in price reset. For this longer period, F&S assume the same input price growth rate of -0.09% as they did for 2005-2014, while BLS KLEMS computes an input price growth rate of 1.53% for this period. This differential of 1.62% implies that F&S would calculate a TFP level of 0.26%, or 1.62% less than the BLS KLEMS figure of 1.88%. Thus F&S TFP and input price growth would again leave the calculated X factor unchanged from what would have been calculated by BLS KLEMS for this period.

[10] According to the BEA, Broadcasting revenues were about $128 billion of the $710 billion in revenues for the combined Telecommunications and Broadcasting Industry in 2015, leaving Telecommunications with $582 billion. CTIA figures suggest that wireless telecommunications is $192 billion of this, and assume that satellite and other wireless communications are about $30 billion. This leaves approximately $360 billion, or 51% of the combined industry as wired telecommunications. See https://www.census.gov/econ/currentdata/dbsearch?program=QFR&startYear=2000&endYear=2016&categories=517&dataType=101&geoLevel=US&notAdjusted=1&submit=GET+DATA&releaseScheduleId= ; https://www.census.gov/econ/currentdata/dbsearch?program=QFR&startYear=2000&endYear=2016&categories=515&dataType=101&geoLevel=US&notAdjusted=1&submit=GET+DATA&releaseScheduleId= ; and http://www.ctia.org/your-wireless-life/how-wireless-works/annual-wireless-industry-survey.

illustrates the dangers of attempting to piece-part out the financials of an industry using a mix of non-comprehensive and idiosyncratic data estimates.[11]

To continue the sanity check, assume that F&S's implausible implication for broadcasting and wireless input prices is correct and that these prices did rise by 3.0% per year over this period. Because F&S's analysis presumes that TFP is uniform across the combined industry, this difference in input price growth would imply that output prices in the broadcasting and wireless telecommunications sectors must have increased much faster than the output prices in the wired telecommunications sector. But this did not occur.

Table 1 shows annual growth rates over the 2005-2014 period in the Producer Price Indexes for the various sub segments of the telecommunications and broadcasting industries: wired telecommunications (NAICS 517110), wireless telecommunications (NAICS 517210), cable television programming (NAICS 5152), and radio and television (NAICS 5151). As Table 1 shows, wired telecommunications prices rose over this period while wireless telecommunications dropped, as did radio and television (i.e., broadcasting) prices. While cable television programming prices (also part of the broadcasting subsector) increased over this period, given that cable programming revenues are only slightly less than radio and television revenues, and are less than a third the size of wireless telecommunications revenues, it is mathematically impossible for their increase in price to cause overall broadcasting and wireless telecommunications prices to rise – let alone rise faster than wired telecommunications prices. Thus, the empirical evidence on actual input and output prices in the telecommunications and broadcasting industries provides sanity checks that reject the validity of the F&S analysis and its mixture of source data.

Table 1
Output Price Growth for Segments of the Broadcasting and Telecommunications Industry 2005-2014[12]

Industry Category	Annual Growth
Wired Telecommunications	1.24%
Wireless Telecommunications	-3.44%
Cable Television Programming	2.84%
Radio and Television	-0.26%

[11] We note that F&S use a variety of time periods and assumptions in arriving at their input price growth estimates. The price of labor, which is the single largest cost component in the F&S input price calculation, is based on a figure for the annual percentage change between 2001 and 2014. The price of land is based on the annual percentage change over the 2000-2015 period, while the time periods used to project the price changes for the other input components are undocumented. If instead of using the 2005-2014 period for calculating F&S's implication for input price growth outside of the wired telecommunications subsector, we compute this implication for the 2001-2014 period with more closely aligns with F&S's actual data, the incongruities become even larger. BLS KLEMS input price growth for the full broadcasting plus telecommunications industry was 2.71%. Coupling this with F&S's assumption of -0.09% growth in the wireline-only sector implies that input prices for the wireless and broadcasting industry must have increased at an average annual rate of 5.4%.

[12] Bureau of Labor Statistics Producer Price Indexes – Industry Data. Radio and Television: PCU5151—5151--; Cable Television Programming: PCU5152—5152--; Wired Telecommunications: PCU517110517110; Wireless Telecommunications: PCU517210517210 (http://www.bls.gov/ppi/).

The economic inconsistencies of such a mismatch between input prices and TFP, and their resulting consequences, were also recognized by Schankerman and Régibeau:

> Finally, there is also a very important conceptual problem with the CACM approach. Any properly derived measure of total factor productivity, that is a critical element of the X-factor, is necessarily accompanied by a corresponding index of input prices. This is a well-known feature in the economic literature on productivity measurement. One cannot simply mix and match an input price index from one source and a productivity measure from another. They go hand in hand, and both derive from the underlying production function generating output. Mixing and matching makes the whole exercise internally inconsistent from an economic perspective. Yet this is exactly what using CACM would require, since that model does not generate estimates of the sector-specific TFP growth. Of course, one can compute such "mixed and matched" numbers, but they are not meaningful. Since the input price index from the CACM is not integrated with the computation of TFP growth, the approach suffers from this critical problem.[13]

Summary

Even without documenting the significant differences between hypothetical CACM networks and the actual networks providing BDS and the inherently arbitrary estimations that underlie F&S's proffered CACM-related input prices and proportions, we have demonstrated, both conceptually and empirically, that simply joining BLS KLEMS TFP data with a CACM-related input price growth series violates fundamental economic relationships that render the special access X factor calculated by F&S meaningless. Indeed, given the linked nature of input prices with TFP, F&S's input price changes (even if they were accurate) would have an exactly counteracting effect on calculated special access TFP, thus leaving the implied X factor unchanged.

Further, if it were appropriate to adjust or replace BLS input prices to develop a claimed more BDS-specific measure, it would be equally appropriate (and, indeed, compelled by consistency) to adjust BLS KLEMS TFP calculations in equivalent fashion to render them more "BDS-specific." Such adjustments have been suggested by Schankerman and Régibeau and imply significant downward adjustments to the BLS KLEMS TFP measure to make it more BDS-specific.[14] This, of course, would reduce the implied BDS X factor.

[13] Mark Schankerman and Pierre Régibeau, Response to the FCC Further Notice: Regulation of DS1 and DS3 Services, August 9, 2016, p. 21.

[14] Mark Schankerman and Pierre Régibeau, Response to the FCC Further Notice: Regulation of DS1 and DS3 Services, August 9, 2016; and Ex Parte presentation to the Commission on "Price Cap Design for Business Data Services" dated August 15 & 16, 2016.

THERE IS NO REASON TO BELIEVE THAT THE CACM-RELATED INPUT PROPORTIONS AND PRICES RELIED ON BY SPRINT PROVIDE A BETTER MATCH TO A BDS INPUT PRICE INDEX THAN THE BLS KLEMS INPUT PRICE INDEX

As their justification for using posited CACM-related input prices to develop a BDS input price index, F&S rely on an assertion that we have previously criticized and found without support. Specifically, in the FNPRM it is claimed that there "are no reasons to think" that either the underlying cost categories in the CACM or rate of change in input prices (apparently those posited by the Commission staff it its response to the CACM peer review) should be different for business versus residential data services.[15] As we previously noted, no proof or evidence supporting this assertion is offered.[16] Contrary to there being "no reasons to think," we believe there are many reasons and much actual evidence to question the validity of using CACM-related input proportions combined with input prices from the peer review response and the subsequent modifications to these by F&S for developing a claimed more BDS-specific X factor.

It is noteworthy that F&S make no effort to empirically establish the validity of their claim (i.e., that wireline commonality between BDS and mass-market BIAS overcomes the substantial differences implied by forward-looking versus embedded, national mass-market versus localized business-specific, and copper TDM versus packet fiber). Although this assumption of cost commonality based on BDS and BIAS being both wireline services is critical to the F&S approach, they do not attempt to support it even on a heuristic basis, let alone with any empirical evidence.

Aside from the disqualifying fact that CACM-related input proportions or prices are not economically consistent with the data underlying the BLS KLEMS development of TFP as documented above, there are a number of reasons to question whether Sprint's proposed input price series is a more accurate match to actual BDS input prices than are the consistent BLS KLEMS input prices. There are four aspects of Sprint's input price development that we find deficient and/or incorrect both as to KLEMS and as to BDS: (1) assumed growth rates for individual input prices; (2) assumed inputs included and input proportions; (3) development of annualized user cost of capital inputs; and (4) allocation of labor to operating expense figures.

Assumed Growth Rates for Individual Input Prices

It is important to note that the CACM model is a static model of a hypothetical, most efficient mass-market broadband network and, as such, the model does not use nor does it generate any type of input price time series. The origins of input price growth rates that F&S rely on and have modified for use in proposing a special access X factor can be traced to the FCC staff response to a 2013 peer review of CACM provided by Professor Hogendorn – who was concerned that the CACM might generate excessive costs for mass-market broadband services over the course of its 6- to 10-year utilization by the Commission to determine universal service subsidies. In response, the Commission staff posited "high" and "low" estimates for ten extremely aggregated cost categories associated with the CACM.

[15] Declaration of Chris Frentrup and David E.M. Sappington, August 31, 2016, p. 6; Federal Communications Commission, Tariff Investigation Order and Further Notice of Proposed Rulemaking, WC Docket Nos. 16-143, 15-247, 05-25 and RM-10593, para 409.

[16] Mark E. Meitzen and Philip E. Schoech, "Assessment of the FCC's Proposed Options for the Special Access Price Cap Factor," June 28, 2016, pp. 11-12.

But, as we understand it, the CACM contains literally thousands of individual input cost items – including dozens to hundreds associated with each of the ten aggregate categories actually reported in the peer review response. For example, the peer review response posits a single rate of growth for all "electronics" prices. In the CACM, we understand there are literally hundreds of individual input prices that would comprise this category. Further there is no reason to believe that the price of a particular piece of loop circuit "electronics" has experienced the same price trajectory as a piece of core network "electronics" such as a router. And there is certainly no evidence or documentation that the FCC staff attempted to determine individual price trajectories within any of its ten gross categories and to compute an appropriately weighted average growth rate for that category from its individual component prices and relative usage shares. Because of the apparent back-of-the-envelope process employed to develop the round number figures for these category price growth estimates, there can be little confidence that they have been determined with any degree of accuracy.

The Appendix of the staff's response to Professor Hogendorn's peer review confirms these concerns, and highlights the weaknesses of these price series, where it states that the posited input price growth rates are essentially just extremely rough assumptions:

> [This appendix] then provides the *assumptions* on input price changes for the ten cost categories … used in the sensitivity tests.[17]
>
> Limited information was available to us on cost movement for the ten cost categories just outlined.[18]
>
> We do not have good data sources for the history of price changes for the following inputs: fiber, poles, conduit, drop, ONT, fiber pedestal, splitters, and electronics.[19]
>
> We believe electronic costs likely fall by a material amount over time, but do not have data appropriate to this cost category.[20]
>
> We do not have a price series that could be associated with the cost of land and buildings used in network deployment.[21]

The assumption-driven nature of the CACM-based input price series is further reinforced by the following admission in the CACM model documentation:

[17] Federal Communications Commission, Peer Review of Connect America Phase II Cost Model, FCC Response to Professor Christiaan Hogendorn, p. 10 [emphasis added].
[18] Federal Communications Commission, Peer Review of Connect America Phase II Cost Model, FCC Response to Professor Christiaan Hogendorn, p. 11.
[19] Federal Communications Commission, Peer Review of Connect America Phase II Cost Model, FCC Response to Professor Christiaan Hogendorn, p. 11.
[20] Federal Communications Commission, Peer Review of Connect America Phase II Cost Model, FCC Response to Professor Christiaan Hogendorn, p. 11.
[21] Federal Communications Commission, Peer Review of Connect America Phase II Cost Model, FCC Response to Professor Christiaan Hogendorn, p. 12.

> There is no existing readily available source for detailed cost by technology by operating cost category, by geographic area, by density which is aligned with accessible cost drivers. This is the type of information that is needed in a forward-looking modeling effort. Rather, there are a limited number of relevant data points found across an array of information sources. This implies that developing data sources which are inputs into CACM processing will be complex.[22]

Returning to the purpose of the peer review response input price estimates, Professor Hogendorn was concerned that if input prices dropped over time or technology improved, total network costs computed today by the CACM may prove to be overstatements of future network costs. To assuage these concerns and to suggest that total network costs computed today by the CACM would not exceed those of tomorrow, the FCC staff took the conservative path of choosing to err on the low-growth side for its input price growth projections.[23] This is noted by the staff as follows:

> [T]hese assumptions, which are designed to understate CAM cost growth ….[24]

That this goal of ensuring that total network cost estimates were not overstated guided the choice of price growth estimates for inputs is also made clear by the staff.

> We believe that fiber prices rarely decline faster than an annualized rate of 5 percent, and so, leaning toward understatement of cost growth, we use a 5 percent decline in fiber prices in our sensitivity tests. USAC's cost modeling contractor (CostQuest) estimated an annual two percent decline in fiber costs based on work it does for its private-sector clients.[25]

> We believe electronic costs likely fall by a material amount over time, but do not have data appropriate to this cost category. Accordingly, leaning toward understatement of cost growth, in our sensitivity testes we apply a range of annual cost declines of -30 to -10 percent to electronics. We believe that this range is likely to underestimate the actual reasonable range of price movements in electronics.[26]

Thus, not only does the FCC staff state that these input price change values are likely to be inaccurate, it is clear that this inaccuracy is intended to shade towards underestimates of input price growth. Nowhere do F&S acknowledge these characteristics of their "data" that the FCC staff writing the peer

[22] Connect America Cost Model (CACM) Model Methodology, December 22, 2014, p. 27.
[23] This is because the more the staff assumed that input prices would rise, the easier it would be to conclude that the CACM would not overestimate future network costs – which would defeat the purpose of the exercise.
[24] Federal Communications Commission, Peer Review of Connect America Phase II Cost Model, FCC Response to Professor Christiaan Hogendorn, p. 1.
[25] Federal Communications Commission, Peer Review of Connect America Phase II Cost Model, FCC Response to Professor Christiaan Hogendorn, p. 11.
[26] Federal Communications Commission, Peer Review of Connect America Phase II Cost Model, FCC Response to Professor Christiaan Hogendorn, p. 11.

review response clearly stated.[27] And nowhere do the subsequent computations of F&S based on these data attempt to correct for these biases. It is therefore not surprising that the input price index developed by F&S significantly understates the input price index developed by BLS KLEMS.

It is useful to focus on a few of the more significant input categories to illustrate the arbitrary and likely misleading nature of the raw input price growth estimates that F&S subsequently modify to arrive at their overall -0.09% input price growth figure.

First, the electronics category is ambiguous as to what equipment it contains and how this equipment corresponds to equipment actually used to provide BDS. Also, as noted above, it has a large, undocumented assumed negative growth rate of between -10% to -30%. There appear to be no data underlying this range, only the statement above that indicates this range of negative growth rates is based on a belief that these figures represent a lower-bound estimate for how much electronics costs are likely to change over time.

For land and buildings, it is stated that "[w]e do not have a price series that could be associated with the cost of land and buildings used in network deployment."[28] Instead, the proposed estimate is based on national indexes for all property, core commercial, industry and office real estate prices. Again, none of these measures of real estate cost is specific to telecommunications networks and service needs, let alone the provision of BDS.

For fiber, poles, conduit, drop, ONT, fiber pedestals and splitters (fully seven out of their ten categories of capital), F&S admit no potential error or range of uncertainty in their estimates of annual price growth: their "low" estimate exactly equals their "high" estimate. The assertion of such precision to these round number figures in the absence of any supporting data is meaningless.

As we document below, labor prices are by far the most significant input parameter based on cost share in the Sprint calculations. Changes in labor prices posited in the peer review response were based on the BLS Occupational Employment Statistics for 2002-2012.[29] This source changed to the BLS Quarterly Census of Employment and Wages for 2001-2014 in the FNPRM.[30] The FNPRM reports labor prices for the categories of: All Industries, Telecommunications, and Wired Telecommunications – which grew at annual rates of 2.72%, 2.77% and 2.47%, respectively over the 2001-2014 period. [31] In contrast, over the same period the KLEMS labor price index for telecommunications plus broadcasting increased at an annual rate of 3.49%. For their further calculations, F&S used 2.47% as a "low" estimate of labor price growth and 2.77% as a "high" estimate.

[27] Note, however, that these warnings written by the peer review response authors were also not acknowledged in Appendix C of the FNPRM.

[28] Federal Communications Commission, Peer Review of Connect America Phase II Cost Model, FCC Response to Professor Christiaan Hogendorn, p. 12.

[29] Federal Communications Commission, Peer Review of Connect America Phase II Cost Model, FCC Response to Professor Christiaan Hogendorn, p. 11.

[30] Federal Communications Commission, Tariff Investigation Order and Further Notice of Proposed Rulemaking, WC Docket Nos. 16-143, 15-247, 05-25 and RM-10593, Appendix C, para 9.

[31] It is unclear why the FNPRM chose to use this more highly compressed collection of labor price growth estimates when those that it selected for the CACM peer review response ranged from a low figure of 0.9% to a high figure of 3.6%, or a spread of 2.7% rather than the 0.3% spread used here. If the far wider range of values reported in the peer review response had been employed in the development of implied values for the X factor, it would make clear that this particular methodology for determining an X factor is highly inexact.

A major problem with F&S's data source is that the Quarterly Census of Employment and Wages reports only the annual salaries paid to workers, and excludes the large portion of labor's "price" that is not strictly wages. In contrast, the labor price used and reported by BLS KLEMS is a comprehensive labor price for the industry that includes all labor-related costs including fringe benefits.[32] These costs include employer contributions to health care premiums, employer social security contributions, worker compensation costs, overtime pay, and employer retirement plan costs, etc.[33] Over the time period in question (2001-2014), fringe benefit costs, especially for employer-paid healthcare premiums, rose at a much faster rate than paid wages.[34] Therefore, it is not surprising that the wage index employed by F&S underestimates significantly the actually relevant fully-loaded labor price for this productivity analysis.[35] The importance of this understatement of labor price growth for F&S's development of the X factor is immense because F&S assume that capitalized labor costs represent almost 60% of all capital costs, and even higher fractions of various operational expenditure costs.

Inputs Included and Assumed Input Use Proportions

To develop estimates for total input price growth, the posited growth rates for individual input items need to be weighted by the share of each in total network cost. For this weighting Sprint has used the results of a national run of the CACM. The assumed input categories and input proportions for capital-related costs used by F&S are reproduced in Table 2. But there is little reason to believe, and no reason is given, that the capital input mix displayed in Table 2 provides any close match to the mix actually used by ILECs to provision the BDS services that are to be subject to this price cap X factor.

[32] The price of labor is equal to total labor compensation divided by the quantity index of labor. Labor compensation is equal to wages and salaries of employees, plus employers' contributions to social insurance and private benefit plans and all other fringe benefits, in current dollars. An estimate of the wages, salaries, and supplemental payments for the self-employed and unpaid family workers is included. See Michael J. Harper, et.al., "Nonmanufacturing industry contributions to multifactor productivity, 1987–2006," Monthly Labor Review, June 2010, p. 31 (footnote 28).

[33] For a contrasting definition of wages and salaries used in the Quarterly Census of Employment and Wages see http://www.bls.gov/cew/cewfaq.htm.

[34] See, Kaiser Family Foundation, "Employer Health Benefits: 2015 Annual Survey," p. 90, available at http://files.kff.org/attachment/report-2015-employer-health-benefits-survey. Indeed, a reason often given for the relative wage stagnation over this period is because the cost of healthcare premiums and other fringe benefits was rising so fast.

[35] Indeed, F&S's labor cost measure of just wage rates is not even appropriate as an input parameter to the CACM, which demands as its labor input price a fully-loaded wage rate (i.e., one that includes the cost of all employer-paid fringe benefits and pay supplements, etc.).

Table 2
CACM Capital Expenditure Categories and Shares[36]

Fiber	2.9%
Poles	1.2%
Conduit	2.2%
Drop	1.4%
ONT	9.1%
Fiber pedestals	2.7%
Splitters	5.7%
Electronics	6.4%
Labor	59.6%
Land & buildings	8.7%

These CACM input categories and national use proportions are based on a static, hypothetical, forward-looking mass-market FTTH packet-based broadband network with built-in voice capability. Further, the broadband access network architecture modeled by CACM is a passive optical network (PON). These characteristics are in substantial contrast to the DSn BDS networks at issue here. In particular, we understand that:[37]

- BDS networks have been built over the past 50 years using the blend of technologies that was available at the time. They were not built to a uniform technology that is forward-looking as of today. Further, the CACM is a scorched node proxy model that instantaneously places a new uniform network using the existing wire center locations of the incumbent provider using forward-looking, least-cost technologies. It then links these wire centers to customer locations assuming all-at-once optimized cable routes and cable sizes along roads now existing. In this approach, this efficient hypothetical firm will provide a limited set of mass market services (here, best-effort FTTH BIAS with VoIP) unconstrained by any sunk investment and therefore unconstrained by past decisions about its network architecture, services or particular customer base.
- BDS networks were not built nationwide to serve all residences and business locations with mass-market best-effort broadband service. They were built only to the particular subset of business locations that demand BDS, and they comprise specially engineered and designed circuits individually built to serve the idiosyncratic and highly variable BDS demand that has existed and evolved at each particular location.
- BDS DSn services are largely provided over copper-pair access networks, not fiber. Further, these networks employ TDM technology dating from the 1960s. They do not employ more modern packet technology.

[36] Declaration of Chris Frentrup and David E.M. Sappington, August 31, 2016, Appendix Table 1.
[37] An appendix to these comments contains a fuller comparison between the CACM network design assumptions from its documentation versus the characteristics of the actual networks that provide BDS. See, also our discussion of the differences between CACM inputs and the actual wireline networks that provide BDS contained in Mark E. Meitzen and Philip E. Schoech, "Assessment of the FCC's Proposed Options for the Special Access Price Cap Factor," June 28, 2016, pp 10-12.

- BDS networks employ active two-way electronics to provide guaranteed symmetrical full-rate bandwidth to all of their customers. They generally do not employ PONs which are most commonly used to serve asymmetrical (i.e., more download than upload) residential demands at high contention (i.e., over-subscription) rates.[38]

This last bullet point is especially important. As the Commission has found in the instant FNPRM:

> BDS is distinctly different from the mass marketed, "best efforts" broadband Internet access services (BIAS) provided to residential end users, … As such, BDS tends to cost substantially more than "best efforts" services and offered to businesses, non-profits, and government institutions that need to support mission critical applications and have greater demands for symmetrical bandwidth, increased reliability, security, and service to more than one location.[39]

Indeed, because of these cost and performance differences the FNPRM proposes to exclude BIAS services such as are modeled by the CACM from consideration as competitors in BDS markets.[40] Moreover, a number of inputs included in Table 2 are not even used by BDS (e.g., splitters, fiber pedestals and ONTs), or are used in significantly different proportions (e.g., fiber and electronics). It is not at all obvious that "there are no reasons to think that either (1) the underlying cost categories of the CACM or (2) the rates of change in input prices of these cost categories would be significantly different for business data services than for residential data services."[41] Rather, there are ample reasons to believe that these CACM cost categories and posited input price changes are both highly inaccurate representations of BDS cost characteristics and are shaded to be inaccurate in one direction. For example, the mass-market BIAS plus voice network modeled by the CACM is of a decidedly different purpose, scope and technology from BDS networks, and the CACM network optimizations and input value assumptions offered in the peer review response were intended to provide underestimates of total network cost and input price growth. F&S's Declaration provides no analysis, nor any theoretic or empirical evidence suggesting the contrary.

But even if, contrary to all presented evidence and logic, these input price growth estimates and raw input share proportions were accurate for BDS, the further manipulations by Sprint to these data do nothing to make them suitable for acting as an appropriate series for input price growth consistent with productivity analysis principles.

[38] See Federal Communications Commission, Tariff Investigation Order and Further Notice of Proposed Rulemaking, WC Docket Nos. 16-143, 15-247, 05-25 and RM-10593 paras13-14, 34-35, 191 and 194 for a discussion. We have also benefited from discussions with AT&T on these network architecture issues.
[39] Federal Communications Commission, Tariff Investigation Order and Further Notice of Proposed Rulemaking, WC Docket Nos. 16-143, 15-247, 05-25 and RM-10593, para 13.
[40] Federal Communications Commission, Tariff Investigation Order and Further Notice of Proposed Rulemaking, WC Docket Nos. 16-143, 15-247, 05-25 and RM-10593, paras. 190-196.
[41] Declaration of Chris Frentrup and David E.M. Sappington, August 31, 2016, p. 6.

Capital Cost Annualization

The input prices for capital goods employed by KLEMS TFP methodology require these prices to be economic user costs for the capital goods.[42] This is what some call the "rental price concept." As such, these prices must account for all factors that may influence the value of a capital good. These factors include not just the physical depreciation of the capital, but also its cost of removal and salvage value, changes in its value due to interest rate or other finance cost changes, changes in its liability for tax payments, and finally, changes in its value due to changes in technology or the price of newer pieces of substitutable capital equipment. These concepts are well-known in the economic literature and were formalized by Jorgenson.[43]

Agreeing with our earlier observation that the input price growth for the different capital categories reported in the CACM peer review response are intended simply to be changes in the purchase prices for new equipment and that these are inappropriate for direct use as KLEMS input prices, F&S propose some changes to account for the fact that capital goods have a physical depreciation component, a finance component and a tax component. Unfortunately, their computations fail to account for the cost-of-removal and salvage value components, changes in their finance or tax components, and change in capital goods value due to technological or price changes for newer, substitutable goods. All of these omitted components are critical to the concept of the economic cost of capital goods use. Because of these omissions or incorrect calculations, it is impossible for F&S's input price index to be an accurate representation of the capital goods input price changes applicable to a proper productivity analysis.

First, the depreciation lives that F&S claim for their various CACM capital components are not "Economic Lives." Rather, they are what are called "Projection Lives." These lives are simply the length of time newly installed capital plant is expected to remain in service before it is retired.[44] Next, even though the CostQuest spreadsheet relied on by F&S notes the necessary adjustment for "Future Net Salvage," they make no attempt to adjust these projection lives for this component of economic depreciation. Further, this component is both significant (e.g., worth up to 75% of the item's purchase cost) and highly variable across different capital categories. F&S go on to apply the projection life for "Switching" to the cost categories of ONT and electronics. This is extremely curious for several reasons.

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[42] See the *BLS Handbook of Methods*, Chapter 11 (available at http://www.bls.gov/opub/hom/pdf/homch11.pdf); and "Technical Information about the BLS Multifactor Productivity Measures" (available at http://www.bls.gov/mfp/mprtech.pdf).

[43] See Dale W. Jorgenson, "Capital Theory and Investment Behavior," American Economic Review, 53:2, May 1963, pp.247-259; Dale W. Jorgenson, "The Economic Theory of Replacement and Depreciation," in Econometrics and Economic Theory, W. Sellekaerts, ed., (New York, MacMillan; 1973), pp.189-221; and Dale W. Jorgenson, Productivity, Vol. 3: Information Technology and the American Growth Resurgence, (MIT Press, Cambridge; 2005), pp. 147-200.

[44] It is possible that F&S mistook the figures listed on CostQuest's blog spreadsheet to be Economic Lives because this spreadsheet originally listed these as Economic Lives. But they were incorrectly captioned. These are the projection lives for these capital classes – as now indicated in the revised spreadsheet on the CostQuest website. See, http://www.costquest.com/blog/post/gm-and-mapping-breakout-revision. Further, these projection lives substantially match the lives established for these general capital classes utilized in the 1999 HCPM model of the Commission. See, "Forward-Looking Mechanism for High Cost Support for Non-Rural LECs," *Tenth Report and Order* CC Docket. Nos. 96-45 and 97-160, released November 2, 1999 at ¶¶ 419-431 and Appendix A, Part 3. Available at https://apps.fcc.gov/edocs_public/attachmatch/FCC-99-304A1.pdf and https://apps.fcc.gov/edocs_public/attachmatch/FCC-99-304A3.pdf. Note that these documents also incorrectly captioned projection lives as economic lives.

One is that BDS networks contain no switches, thus application of any life associated with the capital category of switching is not pertinent. The other is that there is a far more obvious capital category that might be associated with ONT and electronics. It is Circuit Equipment. While there may not be a large difference in the projection lives of these two categories in the CACM, this choice further diminishes the veracity of their analysis.[45]

Second, we understand that the Projection Lives used in the CACM are almost unchanged from those used in the BCPM, HAI and HCPM models developed in the mid- to late-1990s. Further, the projection lives used in those models were themselves the product of various RBOC depreciation studies from the 1980s and early 1990s.[46] Thus, the most recent actual depreciation data that they reflect is well over twenty years old. Given the changes in both technologies and business conditions and velocity since then, they are highly unlikely to be accurate indicators of today's projection lives.

Third, F&S make no attempt to account for changes in interest rates or other costs of finance over the relevant period. Such changes are simply assumed away – as are possible changes in the tax treatment of capital assets.

Fourth, the degree of price inflation or deflation for new assets will have a significant impact on investment decisions, as it affects the level of productive services required in a given year for the investment to be profitable. As Jorgenson points out, the relevant "rate of return" for the user cost of capital is a real rate of return, where the real rate of return is the difference between the nominal rate of return and the asset-specific rate of inflation in the purchase price of the asset.[47] A classic example is investment in land. If the cost of capital is 10%, but land prices are increasing 9% per year, then the productive services required from land in order for the investment to be profitable is only 1% of the land value each year. On the other hand, the price of electronics has been declining, and the anticipated future reduction in electronics prices factors significantly in the investment decision. F&S have a "low estimate" of -30% and a "high estimate" of -10% per year for changes in the price of new electronics equipment. The services provided by that equipment in any year must cover its opportunity cost of capital, its depreciation, and the future reduction in price for new equipment. Otherwise the investment will not be profitable. Further, F&S's failure to account for these extraordinarily high negative growth rates in their development of capital input prices creates a severe downwards bias to their input price index. If F&S are correct that electronics equipment prices decline at these substantial rates, then incorporating this price decline into a calculation of the rental cost of this capital would imply a rental price that is hardly falling at all, let alone at between -10% and -30% per year.

[45] FS also appear to depreciate the Land portion of their Land and Buildings capital category. This is completely inappropriate and does not comport with proper TFP or depreciation methodology. This is another indicator as to the general incorrectness of their approach and analysis.

[46] See, "Forward-Looking Mechanism for High Cost Support for Non-Rural LECs," Tenth Report and Order in CC Docket. Nos. 96-45 and 97-160, released November 2, 1999 at ¶¶ 419-431. Available at https://apps.fcc.gov/edocs_public/attachmatch/FCC-99-304A1.pdf. See, also, "1998 Biennial Regulatory Review - Review of Depreciation Requirements for Incumbent Local Exchange Carriers," *Report and Order* in CC Docket No. 98-137 and *Memorandum Opinion and Order* in ASD 98-91, released December 30, 1999. Available at https://apps.fcc.gov/edocs_public/attachmatch/FCC-99-397A1.pdf.

[47] Dale, W. Jorgenson, Productivity, Vol. 3: Information Technology and the American Growth Resurgence, (MIT Press, Cambridge; 2005), p. 155.

Finally, in developing an index of the average change in input prices, it is necessary to weight the change in each category's input price by its share of total costs. But the input cost shares that F&S use to weight their capital prices are not those that are actually associated with these capital prices. Rather they are the shares generated by the CACM model that employs different input prices for capital goods. Therefore, even if F&S's proposed capital goods prices are correct, they are weighted incorrectly and form no valid measure of average input price growth.

In sum, the capital goods pricing approach used by F&S is inconsistent with the approach used by BLS KLEMS productivity analysis. KLEMS uses a consistent methodology to measure TFP and input prices, and these two measures are mutually dependent on each other. The BLS KLEMS methodology requires use of the economic user cost/rental approach to measure the prices of capital inputs. F&S appear to use partial book accounting methods that are inconsistent with the economic rental price approach. The rental price concept is based on economic depreciation and economic revaluation due to capital gains or losses in the plant's value. The F&S method is based on a straight line accounting concept of depreciation and, importantly, does not address the economic revaluation of assets that is part of the economic rental price.[48] In addition, they neglect the effects of cost of removal or salvage value. Finally, they fail to develop a weighting scheme that is even consistent with the prices they do adduce. As a result, even if it was economically permissible to merge this input price index with a KLEMS TFP measure that is not based on these input prices, the input price index developed by F&S remains deficient – not just because its raw data are inaccurate as to BDS input prices, but because these raw data are not adjusted correctly to reflect the concept of economic cost, and they are combined with each other to produce an average input price change value that is not consistent with the actual prevalence of these input costs.

Allocation of Labor to Capital and the Development of Operating Expense Figures

Perhaps recognizing that the input price growth estimates for the ten capital categories provided by the CACM peer review response cover only a fractional subset of the complete set of input costs for BDS (i.e., only part of the capital and labor portions of KLEMS, and neglecting the energy, materials and services portions), F&S attempt to bootstrap this fractional capital and labor input price data into claimed figures for changes in operating expense ("Opex") input costs. They claim, without reference to any supporting data, that these operating expenses are overwhelmingly based on labor – with purchased energy, materials and services playing no role – despite their 45% share of total BLS KLEMS expense in 2014.[49] So by F&S's assumptions, labor not only accounts for 59.6% of total capital costs, but also 99% of non-plant-based Opex costs, and very significant portions of plant-specific and plant-non-specific Opex costs. As a result, their final figure for Opex-related input price growth relies most heavily this single assumed input price.

[48] Indeed, F&S's straight-line depreciation paths do not even match the Gompertz-Makeham survivor curve structure that is used in the CACM and has been a part of Bell System depreciation accounting and modeling for nearly 100 years. See, "Forward-Looking Mechanism for High Cost Support for Non-Rural LECs," Tenth Report and Order in CC Docket. Nos. 96-45 and 97-160, released November 2, 1999 at ¶¶ 419-431. Available at https://apps.fcc.gov/edocs_public/attachmatch/FCC-99-304A1.pdf.

[49] While F&S's Tables 4 and 7 in their Technical Appendix refer to "Material" and "Materials Share," these items appear to relate to capital, and not to materials as they are defined and used in KLEMS analyses.

As a threshold matter, just as there is no reason to believe that CACM network capital category shares should match those for a BDS network, there is equal or more reason not to believe that CACM Opex cost levels or shares should match those for a BDS network. The network modeled by CACM is a mass-market network offering only a small range of products or configurations. BDS services are special access services. These are individually designed circuits. Their installation, maintenance, pricing and customer care are handled by completely different organizations than mass-market BIAS – and everything about them is far more subject to individual negotiation and customer-specific arrangement than are mass-market services. For these reasons alone, it is not at all likely that their Opex should match closely that modeled by the CACM for mass-market BIAS services.

In addition, F&S do not develop their Opex input cost shares in a fashion consistent with their development of capital input cost shares. While capital input cost shares are based on a national CACM run, the cost levels for Opex are based on CACM Opex input values for "Large Urban" networks.[50] While it is likely the case that BDS are supplied predominantly by Large Urban networks, this presents a mismatch in aggregating these input costs with capital cost shares that are based on a national profile.

But even more than just a mismatch, this combination creates a downwards bias in F&S's claimed average input price growth. Rural networks, because of their lower customer density and longer loop lengths, are more capital intensive than urban networks. Further, CACM assumes that Large Urban networks have much lower unit Opex expenses than smaller or more rural networks.[51] Because F&S weight changes in capital input prices based on national capital intensity, but weight changes in Opex inputs based on the lower-than-national Opex levels that it believes are characteristic of Large Urban networks, a bias is created that overweights input price changes associated with capital goods and Opex related to capital goods, and underweights input price changes associated with Opex that is not related to capital goods. But because F&S's assumed input price growth rates are lowest for expenditures in the first group, and much higher for expenditures in the second group, a further downward bias in F&S's estimate of overall input price growth is created.

Summary

Quite simply, the CACM, and input prices associated with it, were not designed for the purpose to which F&S are attempting to use them in this proceeding. The fact that CACM may be intended to provide costs for a "wireline network" does not overcome the clear differences in the technologies and input mixes between the CACM-based wireline models and the actual networks providing BDS, not to mention the admitted arbitrary construction of a historical series of these prices.

OTHER ISSUES THAT UNDERMINE SPRINT'S PROPOSAL

There are a variety of other issues that undermine the veracity of the F&S approach to establishing the BDS X factor. These include the wide-ranging results produced by their approach, and the choice of time frame for establishment of the X factor.

[50] Declaration of Chris Frentrup and David E.M. Sappington, August 31, 2016, p. 7, footnote 9.
[51] Declaration of Chris Frentrup and David E.M. Sappington, August 31, 2016, Technical Appendix, p. 7, footnote 9.

CACM Still Produces Wide-Ranging, Unreliable Results Whose Precision is Overstated by F&S

The speculative and volatile nature of CACM-related measures was noted in our initial comments that called into question the reliability of CACM-based input prices and their suitability for use as the input price component of the X factor.[52] The modifications that F&S have made to CACM-related input prices and proportions do nothing to make these figures less speculative or more accurate, and quite likely push them in the opposite direction. The F&S input price estimates already vary widely from -0.76% to 0.58% (a range of 1.34%)[53] with resulting X factor calculations for the 1997-2014 time period ranging from 3.27% to 4.61%.[54] But even this wide range substantially overstates the actual precision of F&S's estimates. This is because F&S have used apparent artificially compressed ranges for their input values. As noted earlier, seven out of the ten CACM capital categories are specified simply by point estimates with no uncertainty range at all. Further, the important labor price input is specified with a claimed uncertainty range of only 0.30%, even when this input was specified with a much larger uncertainty range of 2.7% in the staff's peer review response. Specifying more reasonable uncertainty ranges for these capital and labor cost variables would easily expand the uncertainty range for F&S's calculation of a X factor that could be five to eight times wider than they claim.

2005-2014 Remains the Most Appropriate Time Frame for X Factor Determination

We have stated that to determine the appropriate forward-looking X-factor from historical data, it is important to balance the need for stability in the X-factor number with basing the results on recent productivity and market trends.[55] Balancing these considerations led us to conclude that the appropriate period for setting the X factor is the 2005-2014 period.

The argument advanced by F&S for using the longer 1997-2014 period is specious. They argue that 2005-2014 data are too contaminated by the Great Recession. This is wrong. First, the recession period of 2007-2009 only accounts for three out of the nine years of this test period. Second, their assessment that "TFP growth during this time period may well understate the TFP growth that is likely to prevail during the upcoming phase of price cap regulation" is completely irrelevant.[56] The X factor is based on the difference between telecommunications TFP growth and national TFP growth, not the absolute value of telecommunications TFP growth. Thus, only if the recession depressed telecommunications TFP growth by more than it did national TFP growth would the recession have an effect on the X factor. But it did not. BLS KLEMS shows that over the recession years of 2007-2009 telecommunications TFP growth exceeded national TFP growth by 1.20% (0.52% vs. -0.68%), almost exactly the same amount as the divergence of 1.17% that occurred over the entire 2005-2014 period (1.60% TFP growth for telecommunications vs. 0.43% nationally).

In any event, there is no basis for using this longer period because F&S have no input price data that can be associated with this particular period. Their data for capital categories comes with no specific time

[52] Mark E. Meitzen and Philip E. Schoech, "Assessment of the FCC's Proposed Options for the Special Access Price Cap Factor," June 28, 2016, p. 14 and Table 2.
[53] Declaration of Chris Frentrup and David E.M. Sappington, August 31, 2016, p. 7 and Tables 1 and 2.
[54] Declaration of Chris Frentrup and David E.M. Sappington, August 31, 2016, Table 2. Further, using a midpoint within these ranges provides little comfort or added credence.
[55] Mark E. Meitzen and Philip E. Schoech, "Assessment of the FCC's Proposed Options for the Special Access Price Cap Factor," June 28, 2016, p. 9.
[56] Declaration of Chris Frentrup and David E.M. Sappington, August 31, 2016, p. 10.

period attached to it. Their data for labor comes from 2001-2014 and their data for land and buildings comes from 2000-2015. Given the fact that these data all come from inconsistent time periods and none is tethered to 1997-2014, this choice of test period appears particularly inapt and further illustrates F&S's reliance on a hodge-podge of mismatched data.

CONCLUSION

Nothing has changed to resolve our original questions and criticisms regarding the use of CACM-related input prices for determining the BDS X factor. Our fundamental criticisms of merging CACM with KLEMS are still valid and have not and cannot be rectified. The undocumented and unreliable CACM input price growth has not been demonstrated to track or even approximate the input price trends of the actual telecommunications networks that provide BDS. To assert otherwise is an article of faith and nothing more. There exist unresolvable and fundamental mismatches on many different levels between CACM-based results, actual networks and the KLEMS measure of TFP that render any X factor based on the pairing of CACM-related input prices and KLEMS TFP inherently faulty. Nothing F&S have done or could have done alters this conclusion.

Perhaps if there was no information on input price growth available to the Commission other than Sprint's incongruous and convoluted numbers, then the Commission might be forced to use it. But there is another input price index available. It was developed by BLS productivity experts to both capture the actual costs incurred by telecommunications carriers and to be consistent with the economic principles that underlie KLEMS TFP analysis. Further, this input price index is the actual index that BLS uses in its development of telecommunications TFP. Given the availability of this index, there is simply no reason to prefer using Sprint's index – let alone to expect that it is at all accurate.

APPENDIX: CACM ASSUMPTIONS COMPARED TO ACTUAL NETWORKS PROVIDING BDS[57]

Category	CACM Build Assumptions	Actual DSn BDS Network
Overall Design	Scorched node	Fully embedded nodes and cable routes
	Forward-looking	Fully embedded
	New network built to all locations	Network as historically built over the last 100 years specifically to those locations demanding BDS. Note that although the CACM may build cable routes to BDS locations, it adds none of the equipment necessary to provision BDS over these cable routes.
	All service locations have access to voice and broadband-capable networks	While it is likely that all BDS locations have access to voice and broadband services, these are provided by separate networks that may only share cable routes and sheaths with BDS.
	Contemporary / real-world wireline systems engineering standards are used for the modeling of the network. More specifically, industry standard engineering practices are used for wireline deployments.	Profile of engineering standards as they have existed over the past 50 years since the beginning of current BDS installations.
	Long-standing capacity costing techniques are used to apportion investments reflecting real-world engineering capacity exhaust dynamics down to the Census Block level.	Many allocations between BDS and other services offered by the same network facilities or structures are inherently arbitrary.
	Network design is based on deployment from known/existing LEC Central Offices (based upon GeoResults Central Office locations).	Largely the same (but via different cable routes).
	The current service providers continue to supply the service area.	Same.
	Smaller companies have the opportunity to join purchasing agreements with other small companies, improving scale economies.	Assume yes.

[57] Source for first two columns is: CostQuest Associates, "Connect America Cost Model: Model Methodology," 2014, Table 2, pp. 17-18 (used with permission).

Coverage	Cable broadband coverage currently based on National Broadband Map (June 2013), supplemented with FCC Form 477 (June 2013) data.	BDS coverage is idiosyncratic to BDS and may not match cable broadband coverage.
	Wireless broadband (fixed) coverage currently based on National Broadband Map (June 2013), supplemented with FCC Form 477 (June 2013) data,	BDS coverage is idiosyncratic to BDS and may not match wireless broadband coverage.
Network	Provides broadband-capable networks capable of providing voice and data services.	Specially engineered (i.e., *special* access) to provide BDS exclusively. Broadband and voice capabilities not considered.
	Voice services provided via VoIP platform.	Voice services are irrelevant and not provided.
	No Time Division Multiplexing (TDM) investments are present.	Investments are 100% TDM. No packet investments are present.
	No Video equipment (including Set Top Boxes) are installed	Little or no video equipment installed.
	Network is built to a steady state, and results represent a steady state valuation.	Network built to constantly evolving standards and demands.
	Plant mix will be specific to each state and can be adjusted as part of an Input Collection.	Plant mix is specific to each local area and historical vintage of installation. No ability to adjust.
	Apportionment of structure, copper, fiber, and electronics will be based on active terminations. For example, working pairs, fibers per DSLAM, etc.	Same.
	The network build (demand used to build the network design) includes special service terminations required by businesses and apportions cost to those services in a consistent manner as used for broadband.	Special service terminations required by businesses are completely idiosyncratic to each customer location. No uniformity exists in BDS demand, even by business location.
	The modeled network ends at the fiber termination on the Cloud; this fiber termination is modeled to an assumed Internet Peering location.	Network is fully end-to-end – with endpoints being other customer locations, other network interface points (e.g., IXPs), etc.

Consistency of assumptions between CACM and actual DSn BDS.

Largely consistent
Modestly consistent
Inconsistent